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Controller based Auto Agricultural System

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***Abstract*— An AUTO AGRICULTURE SYSTEM is not only developed to optimize water used for the agricultural crops but also to reduce the efforts of billions of farmers and to provide exactly the same quantity of water that the crop require. Actual water requirement of crops depend on the moisture content (already present) in soil, actual temperature and relative humidity of the atmosphere, speed of wind and the types of crops, too. In this system, a gateway unit (control unit) handles with the sensor information and triggers actuators (valves). The system is having a distributed wireless network of soil moisture sensor, compost sensors which will be placed in the root zone of the plants. And the wind sensor is placed at 2 meter height with respect to ground level..**

***Index Terms*— microcontroller, solenoid valve, QEI, sensor, irrigation, latitude, sunshine hour.**

I. INTRODUCTION

In the fast paced world we want everything to be automated. Our lifestyle demands everything to be fast, automated and remote controlled. Apart from few things man has made his full life automated. And why not??? In the world of advance electronics, life of human beings should be simpler hence to make life simpler and convenient; an idea of "*CONTROLLER BASED AUTO AGRICULTURE SYSTEM*" is presented, a model of controlling irrigation and other facilities to help millions of farmers. This motivation came from the countries where economy is depends on agriculture and the climatic conditions lead to lack of rains, hence there is a need of smart and efficient way of agricultural activities like irrigation. The farmers working in the farm lands are dependent on the rains and bore wells. Even if the farm land has a water-pump, manual involvement by farmers is required to turn the pump on/off when on earth needed. This method of irrigation, sensor technology is used with microcontroller to make a smart switching device for pump and different solenoid valves.

This paper is organized as follows: Section 2 describes Different auto irrigation methods presently used, in section 3 total water requirement for crop (Numerical Analysis) and in section 4 the system block diagram and working of basic building blocks is explained in brief, section 5 concludes finally, last but not least the references are shown in section 6.

II. DIFFERENT AUTO IRRIGATION METHODS PRESENTLY USED

Presently, research on 'automatic irrigation' is going on. Not only are that some of these methods implemented, too. But they are only having a timer mechanism. For a specific time period solenoid valve is made ON to provide water to the crops. But actual water requirement of crops is not a constant quantity. It depends on the moisture content (already present) in soil, actual temperature and relative humidity of the atmosphere, speed of wind and the types of crops, so real time soil moisture measurement and some

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databases related to the effect of crop type, temperature variation, atmospheric relative humidity variations, wind velocity variations are also required to measure the actual moisture measurement, which is not included in the presently available AUTO IRRIGATION SYSTEM [4][5][6]

In addition to that, here compost sensor is also interfaced. It provides the information regarding the amount of nitrogen, potassium, phosphor present in the soil, which will help to take decision that at what time and how much amount of compost is required? In this system, soil moisture sensor, wind velocity sensor, temperature and RH sensor for atmosphere, compost sensor for soil are to be interfaced to microcontroller.

II. Water Requirement for Crops

There are so many formulas and methods available to calculate the water requirement. [1]

A. Blancy-criddle method
B. Radiation method
C. Pan evaporation
D. Penman's Equation

But from each and every method, Penmann method is only one which gives the result most accurately and uses highest number of parameters as an input. So we are going to use it. [1][3][12]

Penman's equation is based on sound theoretical reasoning and is obtained by a combination of the energy-balance and mass-transfer approach. Incorporating some of the modifications suggested by other investigators is

$$PET = \frac{A\,H_n + E_a\,\gamma}{A + \gamma} \quad [1]$$

Where

PET = daily potential evapo-transpiration in mm per day
A = slope of the saturation vapour pressure temperature curve at the mean air temperature, in mm of mercury per °C (Table 3.1)
Hn = net radiation in mm of evaporable water per day
Eα = parameter including wind velocity and saturation deficit
γ= psychometric constant = 0.49 mm of mercury/ °C

The net radiation is estimated by the following equation:

$$H_{n} = H_a(1-r)\left[a+b\,\frac{n}{N}\right] - \sigma\, T\frac{A}{a}(0.56-0.092\,\sqrt{e_a})\left[0.10+0.90\frac{n}{N}\right] \quad [12]$$

Where

Ha = incident solar radiation outside the atmosphere on a horizontal surface, expressed in mm of evaporable water per day (it is a function of the latitude and period of the year as indicated in Table 3.4)

a = a constant depending upon the latitude Φ and is given by (0.29 cos Φ)
b = a constant with an average value of 0.52
n = actual duration of bright sunshine in hours
N = maximum possible hours of bright sunshine (function of latitude as indicated in Table 3.3)
γ= reflection coefficient. Ranges of values of γ are given below. [15]
σ= Stefand-Boltzman constant = $2.01 * 10^{-9}$ mm/day
T_a = mean air temperature in degrees Kelvin = 273 + °C
e_a = actual mean vapour pressure in the air in mm of mercury
The parameter Ea is estimated as

$$E_{a} = 0.35\left[1+\frac{u_2}{160}\right](e_w-e_a) \quad [12]$$

in which

u_2 = mean wind speed at 2 m above ground in km/day
e_w= saturation vapour pressure at mean air temperature in mm of mercury (table 3.3)
e_a= actual vapour pressure, defined earlier.

TABLE I. SLOPE OF THE SATURATION VAPOUR PRESSURE TEMPERATURE CURVE

Temperature(°C)	A(mm/day)
0	0.30
5	0.45
7.5	0.54
10	0.60
12.5	0.71
15	0.80
17.5	0.95
20	1.05
22.5	1.24
25	1.40
27.5	1.61
30	1.85
32.5	2.07
35	2.35
37.5	2.66
40	2.95
45	3.66

$$e_w = 4.584 \exp\left[\frac{17.27\,\tau}{237.3+\tau}\right] \text{ mm of Hg,}$$

where τ = temperature in °C

TABLE II. MEAN MONTHLY SOLAR RADIATION AT TOP OF ATMOSPHERE HA IN MM

North latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0°	14.5	15.0	15.2	14.7	13.9	13.4	13.5	14.2	14.9	15.0	14.6	14.3
10°	12.8	13.9	14.8	15.2	15.0	14.8	14.8	15.0	14.9	14.1	13.1	12.4
20°	10.8	12.3	13.9	15.2	15.7	15.8	15.7	15.3	14.4	12.9	11.2	10.3
30°	8.5	10.5	12.7	14.8	16.0	16.5	16.2	15.3	13.5	11.3	9.1	7.9
40°	6.0	8.3	11.0	13.9	15.9	16.7	16.2	14.8	12.2	9.3	6.7	5.4
50°	3.6	5.9	9.1	12.7	15.4	16.7	16.1	13.9	10.5	7.1	4.3	3.0

TABLE III. MEAN MONTHLY VALUES OF POSSIBLE SUNSHINE HOURS .N

North latitude	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0°	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1	12.1
10°	11.6	11.8	12.1	12.4	12.6	12.7	12.6	12.4	12.9	11.9	11.7	11.5
20°	11.1	11.5	12.0	12.6	13.1	13.3	13.2	12.8	12.3	11.7	11.2	10.9
30°	10.4	11.1	12.0	12.9	13.7	14.1	13.9	13.2	12.4	11.5	10.6	10.2
40°	9.6	10.7	11.9	13.2	14.4	15.0	14.7	13.8	12.5	11.2	10.0	9.4
50°	8.6	10.1	11.8	13.8	15.4	16.4	16.0	14.5	12.7	10.8	9.1	8.1

III. SYSTEM BLOCK DIAGRAM AND WORKING

As the purpose of this model is to measure the moisture content of the agricultural soil and other parameters like temperature, wind velocity, sunshine, RH by real-time method (to minimize the manual involvement by the farmer), a micro-controller with different sensors are used. The amount of moisture present in the soil is to be sensed by Moisture sensor, the atmospheric temperature and RH is measured by temperature-RH sensor and velocity of wind is sensed by wind velocity sensor As ARM9 cortex m3 (LPC 1768) is having very less power consumption here it is used as a microcontroller. Conductivity based moisture measurement of soil is done using sensor FC 28. As it provides an analog output, inbuilt ADC is used to convert in to digital. To measure the atmospheric temperature and relative humidity sensor DHT 11 is used. It features a temperature & humidity sensor complex with a calibrated digital signal output. It provides the total information of 5 bytes, first two of them represent temperature, another two represent relative humidity serially.

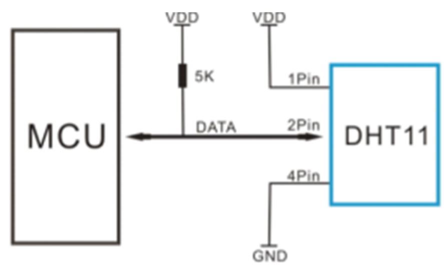

Figure 1 DHT11 interfacing [15] Fig 2 DHT 11 [15]

24 V , 20 A supply is required by a solenoid valve to operate. Actually there are many techniques for its interfacing. One of that is shown in figure4.3. Here to interface the solenoid valve with controller, darling ton transistor pair is required. Instead of using individual darling tons for each valves , here ULN 2003 IC is used [5]

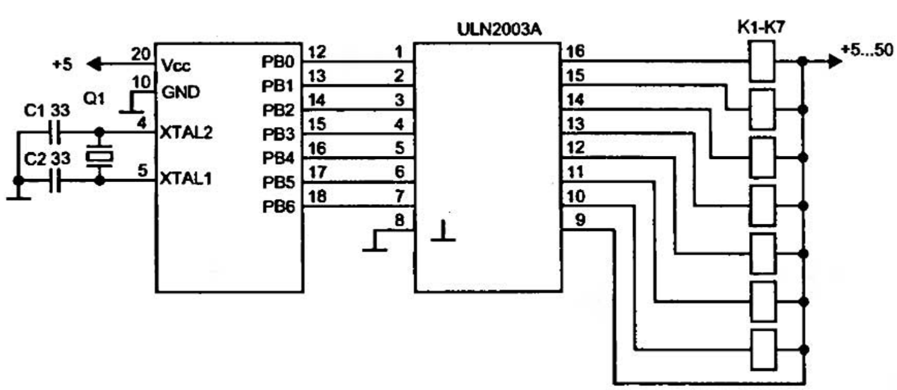

Figure 3 Solenoid valve interfacing

Wind speed can be easily measured using an LED-PHOTO TRANSISTOR pair. As the voltage across LED in forward bias is 0.7 V and current assumed is 5 mA, to compensate the extra voltage drop resistors are connected in series. Now if there is no wing of fan (Baffle) in between LED and PHOTO TRANSISTOR, transistor is enabled and output will be 1.and it will be 0 for the other case. output is connected to any of the pin of controller, by configuring that pin as an interrupt, number of these edges in one minute can be found , which is the wind velocity.

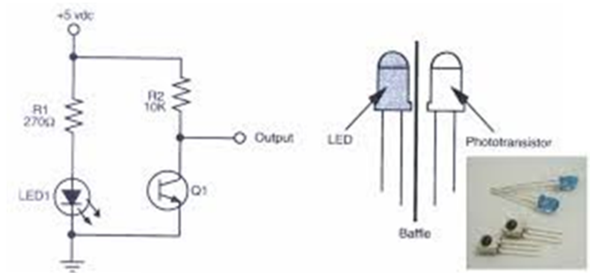

Figure 4 Wind velocity sensor interfacing

After collecting all the data, using penman equation PET (potential evatranspiration rate) is to be calculated by controller. As we know that water requirement for irrigation depends on the types of crop also. So, by multiplying this PET by the crop coefficient (Kc),[1] we can get the actual water requirement for a particular crop. And according to that the time period is to be calculated for which solenoid valve and pump should be ON to provide the water to the field. Not only the irrigation but we can also interface some kind of compost sensor to controller. so that system can itself provide a particular fertilizer whenever it is necessary.

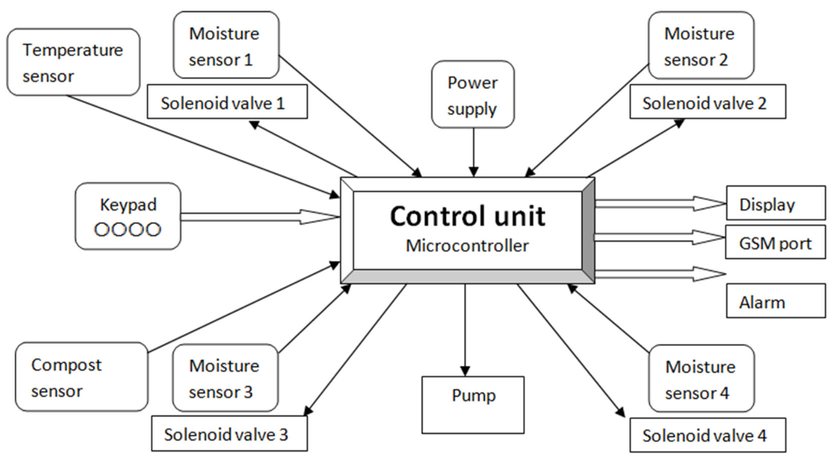

Fig 5 Block Diagram of the system

As it is my dissertation title, Actual implementation of the interfacing of all the sensors with ARM9 to detect the humidity in the soil (agricultural field), temperature, wind speed and supply water to the field according to its requirement is done in all respect. It is a microcontroller based design which controls the water supply and fertilizer requirement in the field to be irrigated. The solenoid valves will not be activated till water is present for the specific crop on the field. Once the field gets dry, sensors will sense the requirement of water in the field, Microcontroller will then supply water to that particular field which has water requirement for some specific time and then valves will be deactivated again. As the size of farm is normally large, using a single sensor we cannot judge the proper moisture content. Therefore there is an arrangement of section wise different sensors and valves.

As a controller NXP LPC1768 microcontroller is selected because of the following features [14]

• ARM Cortex-M3 (ARMv7) 32-Bit CPU

- Up to 100MHz Main (Core) frequency
- 512kB program memory (Flash), 2x32kB RAMS
- Supports ARM Cortex ETM Trace
- 10/100MBit Ethernet, RMI interface, DMA controller
- 12-Bit Analog-Digital-Converter, 8 channels
- 10-Bit Digital-Analog-Converter, 1 channel
- 4 32-Bit width timers
- 6 PWM channels, 1x Motor Control PWM, 8 DMA channels
- USB 2.0 interface with integrated transceiver
- CAN2.0B with 2 channels
- 4x UART, 2x SSP, 1x SPI, 3x I2C, 1x I2S
- Interface for Quadrature encoder
- Low Power RTC, Unique ID
- Internal 4MHz RC oscillator

IV. Conclusion

The paper "AUTO AGRICULURE SYSTEM" includes the automatic irrigation, compost measurement in which wired or wireless network can be used. For an enhancement, options for the modes of irrigation like DRIP irrigation and irrigation using SPRINKLE is also to be provided. Similarly, the options like AUTO and MANUAL can also be provided. In AUTO mode, system work same as discussed earlier and in MANUAL mode, its working is exactly same as the present irrigation systems. In which, Farmer has to select the time interval for which valve is kept ON.

In an analysis and data collection, the reviews and suggestions from various farmers and agriculture experts are taken in to consideration. So it can be really a very helpful system for the farmers.

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